STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

SEPTEMBER ATLANTA, GEORGIA 1949

The Research Engineer

Published in May, September, November, January, and March by the State Engineering Experiment Station of the Georgia Institute of Technology, Atlanta, Georgia. 1949-1950 Volume, Number 2. Entered as second-class matter September 20, 1948, at the post office at Atlanta, Georgia, under the Act of August 24, 1912. Acceptance for mailing at the special rate of postage provided for in the Act of February 28, 1925, Section 538, P.L.&R., authorized October 18, 1948.

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FOOD FREEZING

Napoleon, better known for his military conquests than his skill in logistics, has still gone down in history as the author of the saying, "An army travels on its stomach." In Napoleon's day, army stomachs were filled to a considerable extent by foraging—living on the surrounding country—but in this day and age, in which warfare might range from the frozen wastes of arctic regions to the burning sands of the Sahara, logistics is and must be an exact science as regards food supply as well as the weapons of war.

The food which an army eats must therefore be portable—perhaps for long distances—certainly for indefinite periods of time. To effect this, food preservation methods have received and are receiving careful study—canning, dehydration, food freezing, etc. Each has its merits; each its drawbacks. All are subjects for needed, continued research.

What is of importance to an army is often of equal or greater significance to civilians. In the early days, men ate little that was not grown nearby, driven in on the hoof, or preserved in crude ways with decided changes in taste. Food canning changed this picture considerably but not completely—canned goods rarely looked like or tasted like the fresh products. Food dehydration, much ballyhooed in the early days of the recent war, is also playing a civilian role, but with marked limitations. Food freezing, however, has won and is winning increasing popular favor because frozen products are much more like the fresh foods in appearance, texture, and taste.

Research in the food freezing field has its interesting as well as important aspects. Scientific methods are being

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To the layman, *pure* research, *fundamental* research, *applied* research, and *industrial* research are terms which are far from clear and distinct, a fact which is not particularly surprising when it is considered that they relate chiefly to motivation and not (usually) to actual differences in techniques. A problem which one scientist may study "purely" because he is curious may be of a "fundamental" nature, yet may actually be investigated by another scientist because its solution may be "applied" to a given field or may be needed for some "industrial" application.

This, of course, is an oversimplification. Many "pure" and "fundamental" studies have little or no immediate application, and many applied and industrial research and development investigations are more concerned with "know-how" and the use of available knowledge than they are with adding to the storehouse of information. What *is* important, however, is the fact that each type of research plays a definite role and that all types are interdependent. In an industrial nation such as ours, we must not fail to support an adequate program of "pure" and "fundamental" research if we expect to continue to have knowledge which can later be employed for industrial applications.

BLAKE R. VAN LEER,
President, Georgia Institute of Technology

A CAMERA-CARDIOGRAPH SYNCHRONIZING UNIT

By ROY A. MARTIN*

The camera-cardiograph synchronizing unit described in this article and pictured in the center foreground on the cover of this issue was designed as an aid for medical research dealing with studies of the human heart. These studies are being conducted at the Emory University Medical School by a group of physicians in the Department of Physiology, under the direction of Dr. James V. Warren. The camera-cardiograph unit will not only add to the general fund of medical knowledge but will also aid in the diagnosis of heart ailments, one of the most serious problems in the field of medicine.

A technique for photographing the heart and its action and for recording heart sounds and associated electric body potentials has been developed at Emory University during the past year. This system, shown in Figure 1, consists basically of four components: a fluoroscope, a motion picture camera, a stethograph, and an electrocardiograph. X-rays, produced by a rotating anode machine, pass through the subject and on to a fluorescent screen mounted in one end of a light-tight housing unit; pictures of all subjects opaque to X-rays within the body of the subject are visible on the screen. This arrangement yields much the same results as the ordinary fluoroscopes found in many doctors' offices.

Since the heart is a very dense muscular organ, its outline is clearly shown on the screen. However, in order for a picture of the blood being pumped by the heart to be produced on the screen, a special substance opaque to X-rays, known as diodrast, has to be injected by means of a smooth, flexible tube, known as a catheter, into one of the large veins at its point of entry into the heart. The injection of this dye into the blood stream of the subject has no lasting effects. It does lower the blood pressure somewhat, but this effect is corrected by normal body processes within a few days.

When the diodrast has been injected, the picture produced on the screen shows the heart and its action, the flow of blood as it enters the heart, the flow of blood through the heart, and the dispersion of the blood as it is forced into the arteries leading away from the heart. The 16 mm. motion picture camera, mounted (Figure 1) at the other end of the housing unit in direct line with the screen, produces a photographic record of these effects.

The stethograph and electrocardiograph are combined into one unit and are operated during the time the motion pictures are being made. These instruments record, respectively, sounds made by the heart and the pulse intervals of the heart, and electric potentials of the body associated with the heart. Recordings are made on a special tape.

The overall result of the above technique is a motion picture of the heart and its action and a tape recording of the heart's sounds, pulse intervals, and potentials, all of these bearing a definite time relationship to each other.

NEED FOR SYNCHRONIZING

When early tests made with the above recording devices were studied, it was found

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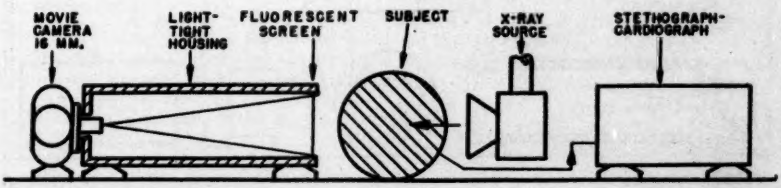

Figure 1. Data recording system.

that the motion picture photographs (that is, the individual film frames) could not be properly related to the respective sounds and potentials recorded on the stethograph-cardiograph tape. Thus, time *a* on the film could not be identified with time *a* on the tape. This was caused by the different rates of movement of the film and tape as the recordings were made since, for different types of subjects and lighting conditions, the speed of the film must be varied so that sharp, clear pictures can be obtained. To overcome this difficulty, a camera-cardiograph synchronizing unit was developed at the Georgia Tech Engineering Experiment Station to provide automatic synchronizing markings for the film and tape, regardless of the speed of either.

This synchronizing system is shown in Figure 2. The data recording device is basically the same as that shown in Figure 1; however, the camera was modified so that a push-rod, operated by the gear system in the camera, drives a microswitch connected to the synchronizing unit. This switch automatically closes once every 30 frames—exactly during the interval that the thirtieth frame is being exposed. As soon as the switch is closed, the synchronizing unit is actuated, and a film-marker lamp, shown in Figure 2, is turned on for approximately 1/240 second, so that an overexposure of the film appears as a dark spot in the upper left-hand corner of the frame. During the time the lamp is on, a square pulse marking signal, of approximately 1/340-second duration, is fed to the stethograph, so that a break in the stethograph trace is produced, wide enough for a definite visible mark on the tape, but not too wide so as to materially obscure any of the recorded sounds. Therefore, every thirtieth frame of the film is marked and a corresponding mark appears on the tape. Thus, regardless of the speeds used, the film and tape are marked off in definite, easily recognizable time intervals. Figure 3 shows the film and tape as marked by the synchronizing unit. It is desirable but not required that the speeds of both the film and tape be fixed during each particular run.

SPECIFICATIONS

The electrical design of the synchronizing unit was influenced greatly by the following physical specifications set forth for the unit: (1) that it be portable and therefore as small as possible, (2) that the unit be simple in operation and have a minimum number of controls, and (3) that the circuits be simple, so as to require minimum maintenance. To comply with these specifications, miniature components were used wherever possible, resistance-capacitance coupling was used throughout, and only one control was installed, the "off-on" switch. A circuit diagram of the unit is shown in Figure 4.

The operation of the unit is started upon the closing of the camera-driven microswitch. When this switch is closed, the d-c voltage from the power supply is applied to the differentiating circuits. The output of these types of circuits is a sharp, positive spike, dependent on the closing of the switch but independent of its opening. The output voltage of differentiating circuit No. 1 is

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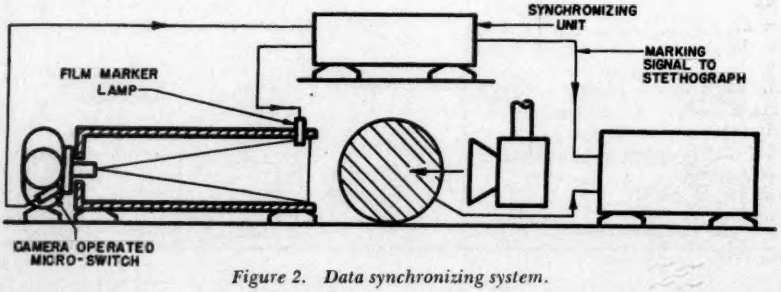

Figure 2. Data synchronizing system.

MEASUREMENT OF THE COLOR OF FOODS

A ROTATING DISC SAMPLE HOLDER FOR USE IN SPECTROPHOTOMETRIC STUDIES

By T. W. KETHLEY,* W. B. COWN,** and F. BELLINGER***

As part of the program on the preservation of foods by freezing being carried out at Georgia Tech jointly with the Tennessee Valley Authority, research has been conducted on the measurement of the color of foods in an attempt to correlate color changes with chemical and physical alterations. The use of color photography has been described in an earlier RESEARCH ENGINEER article, and the following paper presents a review of the problems involved in the color measurement of foods, together with a description of equipment for the solution of certain of these problems. This equipment consists of a disc which holds samples of foods and effectively averages their colors by rotating them, so that an accurate measurement of the color of the sample can be made with a spectrophotometer.

For the past several years a comprehensive program of research on the fundamentals of the preservation of foods by freezing has been conducted at Georgia Tech. The nature and scope of this program has been discussed in an earlier article in THE RESEARCH ENGINEER[1] and elsewhere.[1] In the course of work on this program, it has been found necessary to develop physical, chemical, and biological tests for characterizing changes in the quality of the foods under study. Since color is one of the significant attributes of foods, a great deal of effort has been expended in the study of the measurement of this characteristic, both as an index of change for the furtherance of research and as an index of quality in terms of consumer acceptance.

PROBLEMS OF COLOR MEASUREMENT

The phenomenon of color has a psychological and a physiological basis as well as physical characteristics. That is, color primarily exists because the human eye responds to it. In order for color to exist, three factors must exist: a light source, a colored object, and a receptor to respond to the light stimulus from the colored object. Variations in any one of these causes a variation in the resultant color. Although the human eye, or "normal observer" is the basis for most color specifications, in the instrumental measurement of color it is easier to control the light source and the receptor, thereby making the measurement of the colored object less susceptible to variation. However, the measurement of color by the "normal observer" has been refined to a high degree for certain purposes, and a thorough discussion of the methods involved is to be found in a report by Nickerson.[10]

Instrumental measurement of color at the research level is usually carried out with a spectrophotometer. In this instrument, a source of white light is directed at a device which splits the light beam into its colored components. This device is known as a monochromator and may be a prism or a grating. The light components emerging from the monochromator pass into an optical system which can be adjusted to select light of the desired color and then send it to the sample which is being studied. If the sample is transparent, the light passes through it to some device which measures the amount of this transmitted light. If the sample is opaque, the light from the monochromator is reflected from the sample and then is measured. Because most foods are opaque, the method of color examination by reflection is of greater interest to research on foods. However, whether the sample is studied by reflection or transmission, color is measured by sending light of various wave

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lengths, equivalent to various colors, from the monochromator to the sample and measuring the amount which is either reflected or transmitted. The amount of this light is compared to that transmitted by or reflected from some standard, and the final results are plotted as a curve of reflectance* or transmittance* against the color of the light in terms of wave length. Color can be expressed in terms of wave length because the wave length of the light actually determines the color, as indicated in Table I. Typical reflectance curves are illustrated in Figure 1.

The collection of spectrophotometric data and the plotting of a curve is not all that is required for the analysis of color. The curve resulting from spectrophotometric measurements is useful for many purposes, but it does not concisely describe a color. There are many methods for further carrying out the analysis of colorimétric data, the most important of these being those of the International Commission on Illumination.[5, 6] These are complex but are of such value that, at the demand of industry, equipment has been recently developed which will make a spectrophotometric examination of materials such as textiles and will simultaneously analyze the results. The value of this equipment to certain industries can be roughly estimated from the fact that it costs about $15,000.

Other methods for analyzing the results of reflectance examinations have been devised for the solution of specific color problems. Lott[8, 9] has published information on the analysis of the profile of the reflectance curves which he obtained from the skin and the flesh of maturing apples in an effort to correlate color changes and maturation. Compton, *et al.*,[4] analyzed the reflectance curves which they obtained from the leaves of the apple tree by the I. C. I. method and then translated these analyses into color plaques showing changes in the green color that correlated with the nitrogen content of the leaves. Sendroy and Granville[12] applied the technique of reflectance measurements to the estimation of the concentration of certain chemicals by comparing the reflectance curves of stains made by the unknown with curves of stains made by known amounts of the chemical. Such methods as these are not too complex, but they generally fail to show a quantitative relationship in terms of color changes. Ideally, color changes for a specific set of circumstances should be characterized by numerical values, the size of which bears some quantitative relationship to the color change.

TABLE I

RELATIONSHIP BETWEEN COLOR AND WAVE LENGTHS

Color	Wave Length Range (Millimicrons)
Violet	400-450
Blue	450-500
Green	500-570
Yellow	570-590
Orange	590-610
Red	610-700

PROBLEMS OF COLOR MEASUREMENT OF FOODS

As mentioned, measurement of the color of foods has two prime objectives—to follow variations for research purposes in order to determine the nature of the change, and to note such variations for quality control in terms of consumer acceptance. To fulfill these objectives, it is necessary to measure the color of the intact surface of the food, since it is this surface which will be examined by the consumer and which will most readily show changes caused by processing and storage. The color of extracts or purees made from the foods does not necessarily represent the true color of the food because the physical condition of the surface of the food and the arrangement of the colored matter in pigment granules have a tremendous effect on the final color of the food.

The earliest work carried out at Georgia Tech on the color of foods indicated that the problem of proper sampling is a major one. For example, the irregular size and shape of green beans or strawberries and the nonuniformity of the color of a single bean or berry make the problem of measur-

* *Reflection* is the process by which light incident to a surface rebounds from that surface; *reflectance* is a measure of this process. The same distinction exists between the terms *transmission* and *transmittance*. These definitions are those set forth by the Committee on Colorimetry of the Optical Society of America.[5]

ing the color of these objects much greater than that of measuring the color of flat, uniformly colored objects such as a sample of painted wood. However, certain techniques have been applied to the solution of the problem of color measurement of irregular objects. One of these methods employs the integrating powers of a sphere.[6,12] When light is reflected from an object inside a hollow, uniformly coated sphere, the reflected light energy is distributed equally throughout the interior surface of the sphere. By use of this fact, Rabideau, *et al.*,[12] studied the reflectance of light from certain green leaves. Since these leaves were relatively flat, a relatively small sample was required, making possible the use of a small sphere. Unfortunately, with such irregular shapes as green beans and strawberries, a larger sample would be necessary, and it is estimated that a sphere of about five feet in diameter would be required.

Another method for measuring the color of large, irregular samples is that of spinning the sample at such a rate that the apparent color and shape fuse into a uniform disc. This method has been applied to the visual comparison of agricultural products such as hay or cotton[10] and for the spectrophotometric measurement of the color of thread and cloth.[11] A method has also been devised for the visual comparison of the color of irregular objects by rotating the optical components of the measuring device and maintaining the sample at rest.[10] The early analysis at Georgia Tech of the problems involved in the color measurement of foods indicated that one of these two methods should be applicable to these problems.

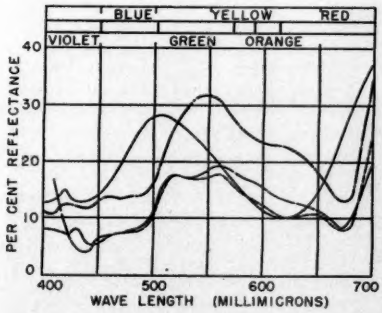

Figure 1. Typical reflectance curves obtained from samples of green beans on the rotating disc. The reflectance curve obtained from a sample of green mat paper is included for comparison (as the solid line).

METHODS STUDIED AT GEORGIA TECH

Results obtained here from reflectance measurements on the color of single objects were unsatisfactory because of the large amount of variation in size, shape, and color of the objects. The application of color photography to the recording of the color of foods has proved very successful,[2] however, and this method has been used extensively at Georgia Tech in the study of changes which take place during the storage of frozen foods over periods of months. This technique consists of making color transparencies of fresh and processed foods under standardized conditions (including photographic development) and subsequently comparing these transparencies with color transparencies made of the foods following freezing and storage. Although this method has been qualitatively useful, it has not served to characterize quantitatively the nature or the amount of color change. Furthermore, it has not yet proved possible to make *true* color prints of these transparencies which could be used for the dissemination of this information to other workers.

Because of this weakness in the method of comparing color transparencies, research on the measurement of the color of foods by other methods has been continued. Green beans were used as test specimens because of their availability throughout most of the year.

For use in spectrophotometric studies, a rotating disc sample holder was constructed. This sample holder was made from a circular needle holder (four inches in diameter) of the type sold for holding flowers in ornamental arrangements. The needle holder was then welded to the spindle of a buffing head and rotated by a motor through belt drive, employing various pul-

ley arrangements to vary the speed. This arrangement is shown in Figure 2.*

Samples of green beans were impaled on the needles as closely together as possible, and the disc was then rotated. It was found that raw green beans would remain on the holder at speeds up to 1,000 r. p. m., although cooked beans were slung off at much lower speeds. Even a speed of 1,000 r. p. m. was not sufficiently rapid for the sample to appear a uniformly colored disc when viewed by the human eye. However, when the outer edge of the sample of green beans on the rotating disc was placed beneath the reflectance accessory of the spectrophotometer and rotated at various speeds, it was found that speeds in excess of 150 r. p. m. gave a steady reading on the spectrophotometer, indicating that the instrument was "seeing" an apparently uniform object. A speed of 370 r. p. m. was selected for subsequent experimental work since this speed is well in excess of that sufficient to give steady readings on the spectrophotometer and not great enough to sling off cooked green beans.

The necessity of comparing reflectance readings against a known standard prompted the construction of the equipment shown in Figure 3. The rotating disc sample holder is mounted in a black box, and a standard Vitrolite block (from the National Bureau of Standards) is mounted in the same plane in another black box. This entire assembly is mounted on tracks at right angles to the spectrophotometer and its reflectance accessory, so that either the standard or the sample can be placed beneath the viewing port of the reflectance accessory. The spectrophotometer is also mounted on tracks for ease of removal for other work. A light-tight seal was made between the reflectance accessory and the rotating disc assembly by fitting a blackened brass plate into channels on the rotating disc assembly so that the plate slides freely and can be pushed tightly against the reflectance accessory. The completed equipment is shown in Figure 4.

Preliminary tests on the equipment shown in Figure 4 proved it to be light-tight to external illumination under all condititons of use. Samples placed on the rotating disc are viewed by the reflectance accessory over a path about one inch wide, inside the periphery of the circle 2.5 inches in diameter—an area equal to approximately two square inches, selected at random from an area of approximately six square inches (the area of the whole disc). The reading taken from the spectrophotometer when the sam-

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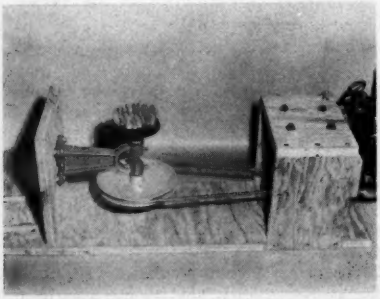

Figure 2. The first model of the rotating disc sample holder.

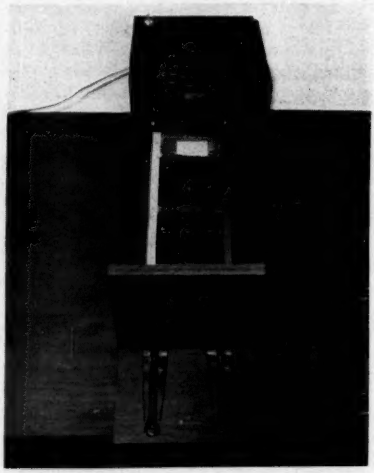

Figure 3. Rotating disc and standard Vitrolite block assembly prior to mounting with the spectrophotometer.

*Acknowledgement is made to J. W. Gabel of the Calco Chemical Division of the American Cyanamid Company for calling attention to the patent of Parks[11] and for other suggestions.

THE STATE ENGINEERING EXPERIMENT STATION 1948-1949

By GERALD A. ROSSELOT* and FRED W. COX, JR.**

This article, essentially a condensation of last year's "Annual Report of the Director," presents an account of the Station's progress during the past fiscal year.

To promote their growing industrial economy, Georgia and the Southeast, in recent years, have recognized the need for a continually expanding supply of young, well-trained engineers and scientists and for well-equipped laboratories staffed with capable research personnel devoted to supplying industrial requirements of applied and fundamental research. Seeking to meet this challenge, the Georgia Institute of Technology has, during the past few years, greatly expanded its facilities for training its students and for undertaking research.

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**Assistant Director, State Engineering Experiment Station.

The cause of pure research at Georgia Tech has been advanced: (1) by the expanded program of the Graduate Division, which is now offering the Ph.D. degree in three fields, and (2) by granting reduced teaching schedules to faculty members who undertake the study of worthy pure research problems. Applied and industrial research has been furthered by the program of the Georgia Tech Engineering Experiment Station, which is charged with coordinating the research undertaken at Georgia Tech for outside agencies.

In addition to outside-sponsored projects, the Station sponsors research of its own on problems of interest to Georgia and this

Figure 1. Central portion of the main Research Building of the Georgia Tech Engineering Experiment Station.

region, and, by offering part-time employment to a large number of graduate and undergraduate students, aids in the training of these students for research positions in industry. By offering part-time employment to research-minded faculty members, the Station aids the various Georgia Tech schools and departments in expanding their teaching staffs; moreover, several members of the Station's full-time staff cooperate with the teaching faculty by offering highly specialized courses and by acting as thesis advisors.

Demonstrating further the soundness of the principles on which it was founded, i.e., of utilizing Georgia Tech facilities on research problems for industry and other outside agencies, the Georgia Tech Engineering Experiment Station during 1948-1949 set new records of achievement. It administered the largest budget in its history, 28 per cent greater than for the previous year; employed more full-time personnel; and offered part-time employment to more students and faculty members than ever before. In addition, it carried out more extensive research programs and improved its research potential by adding several new specialized laboratories. Much of this expansion reflects the splendid cooperation of various departments, schools, and divisions of Georgia Tech in lending personnel and equipment to worthy projects. Among those participating in specific projects were the Schools of Aeronautical Engineering, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Civil Engineering, Ceramic Engineering, Physics, Chemistry, Architecture, and Textile Engineering; the Departments of Public Health and Biology, and Mathematics; the Graduate and Extension Divisions; and the Georgia Tech Library.

BUDGET

Continuing the trend of recent years, the Engineering Experiment Station on June 30 closed its books on the most successful year of its existence. Since July 1, 1942, the annual research volume has steadily mounted to the high of $600,000 for the year just passed. This steady growth is clearly shown in Figure 2, in which is pictured the Station's income from three major sources over the past seven-year period. As may be seen, the expanding budget has been chiefly caused by the rapid increase of research conducted for outside sponsors, since State and endowment income have remained more or less constant. In the year 1948-1949, income from outside sources amounted to 83.5 per cent of the total, while that from Georgia Tech accounted for 14.9 per cent and income from endowments for 1.6 per cent.

PERSONNEL

The diversified research program coordinated by the Station during the past year required the full-time services of 81 persons and the part-time services of approximately 126 others. Of these, 23 were faculty research associates; 3, research professors; 9, research associate and assistant professors; 10, research engineers; 38, research assistants; and the balance, technical assistants, clerical workers, and office personnel.

The expanding activities of the Station required the addition of Dr. Fred W. Cox, Jr., as full-time assistant director to replace Dr. Paul Weber, who had served part-time for several years as assistant director and who resigned to become director of the Georgia Tech School of Chemical Engineering. Dr. Cox, a graduate of Georgia Tech and the University of Wisconsin, brings with him ten years of experience in industrial research and development at The Goodyear Tire and Rubber Company and The Southern Research Institute. Added to the research staff was Dr. R. J. Raudebaugh as Research Professor of Chemical Engineering. Dr. Raudebaugh has a Ph.D. in Metallurgy from Purdue University and has had approximately ten years of experience in university teaching and industrial research. The staff has also been further strengthened by the addition of V. R. Widerquist, M.S. in E.E. (Georgia Tech), Research Assistant Professor; W. B. Wrigley, B.S. in Engineering Physics (Lehigh), Research Engineer; Frank W. Brown, B.S. in Physics (U. of S. Carolina), Research Assistant (Physics Instructor); Robert Caldwell, B.S. in Ch.E. (Georgia Tech), Research Assistant; H. W. Mauldin, Jr., B.S. in E.E. (Georgia Tech), Research Assistant; Maxwell J. Richards, B.S. in Chemistry (Long Island), Research Assistant; E. G. McLeroy, Jr., A.B. in Math. (Emory), Research Assistant; Floyd Peede, B.S. in Textile Engi-

neering (Georgia Tech), Research Assistant; and G. P. Robinson, Jr., B.S. in Physics (Georgia Tech), Research Assistant.

During the year, the Station's staff participated in the activities of 63 technical or scientific organizations. Also, talks on technical or semi-technical subjects were made by members of the staff before over 40 outside organizations. Several members of the staff received outstanding off-campus recognition: Dr. Fred Bellinger, at the request of General Lucius Clay, made a survey of the German chemical industry; Dr. J. E. Boyd was appointed a member of the National Commission on Tropospheric Propagation; and Dr. William A. Edson was made a member of the Subpanel on Frequency Control Devices of the Research and Development Board of the National Military Establishment. Dr. R. S. Ingols was appointed to the Standard Methods Committee and the Subcommittee on Industrial Wastes of the Research Committee of the Sewage Works Federation, while B. H. Weil was appointed editor of a new bulletin to be issued by the Division of Chemical Literature of the American Chemical Society.

FACILITIES

During the year, extensive additions have been made to the Station's research facilities. Part of the basement of the School of Chemical Engineering has been converted into one of the outstanding laboratories in the country for studies in the field of small particle technology. This *micromeritics laboratory* has been equipped with the microscopic and photographic instruments needed for particle size measurement, measurement of fiber surfaces, and other special studies. Additional equipment is being designed and constructed for studies on particle coagulation and coalescence, investigation of charges assumed by particles under various conditions, and rapid determination of particle concentration in various fluids.

Basic equipment has been purchased for a *protective coatings laboratory*. Included are a three-roll paint mill, a Baker Perkins mixer, a large hot-air oven, a two-roll rubber mill, and a small hydraulic press. In addition, equipment has been purchased for a *high-pressure chemistry laboratory*.

In the Aeronautical Engineering Building, a wind tunnel model rotor test stand with

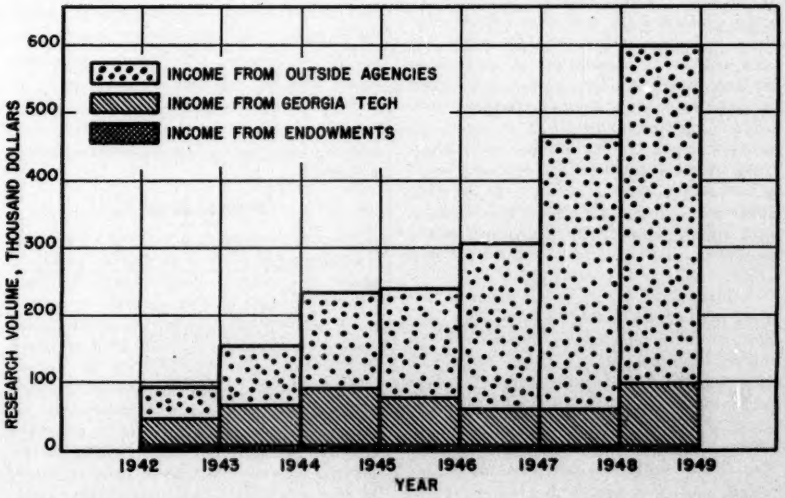


Figure 2. Growth of research volume of the Georgia Tech Engineering Experiment Station, 1942-1949.

integral strain gage thrust, torque, rolling, and pitching moment measuring equipment has been added. A remote-controlled and indicating pitotstatic wake traverse mechanism has also been obtained. A glass bottom water channel (20 feet long and four feet wide) has been constructed and is now in use. This latter piece of equipment permits application of water-channel compressible gas analogies to the high-subsonic, transonic, and supersonic studies of flow about various profiles.

Load-adjuster voltmeters have been added to the Georgia Tech a-c network calculator in order to facilitate adjustments and expedite operations, thus continuing the status of the Georgia Tech calculator as the best equipped in the country. A high-frequency oscillator and a polargraphic instrument have been constructed for use in a project on industrial wastes. An automatic camera-recording weather station, a mobile transmitter station, and special radar equipment have been constructed for use on sponsored projects.

A test chamber including special photographic facilities for determining the overall transmission characteristics of a video system has been set up in connection with research being conducted on television. Equipment for a *noise and vibrations laboratory* has been obtained. Acquisition of equipment has been completed for a *high-speed photography laboratory*, thereby enabling "slow motion" pictures to be taken at speeds up to 6,000 pictures per second and single "stop" photographs to be made at exposures of two millionths of a second. These additions will be extremely useful in industrial work in numerous fields, including textile processing, machine development, fluid flow studies, etc.

Facilities have been expanded for the study of microwave propagation. Also, new equipment has been added to the cellulose and oil seeds laboratories, thus making possible broader research programs in these fields, which are of particular interest to Georgia.

Plans for a much-needed $300,000 addition to the Station Annex have been completed, and it is hoped that funds for its construction may be forthcoming in the next year.

SERVICE ACTIVITIES

The service divisions of the Station have been particularly active during the year. The Engineering Design Division has not only provided the majority of the mechanical design and drafting required by the various Station projects, but has also directed several specialized projects. Increased demand for shop services has resulted in considerable enlargement in the personnel and facilities of the machine and fabrication shop.

The Technical Information Division has continued to serve the project directors by preparing literature surveys, editing reports, and preparing invention records and preliminary drafts of patent applications. A current information bulletin, prepared under the sponsorship of several national companies in the petroleum processing field, was inaugurated during the year and has received wide acclaim. This division has also been active in publication work and the editing of technical articles. Its services as regards literature searches and surveys are being increasingly employed by outside groups.

The Station's Photographic and Reproduction Laboratory has greatly expanded its facilities. In addition to new photographic equipment, a Veritype machine and offset printing equipment have been installed. The laboratory now offers to the Station's projects extensive printing and binding facilities for reports, business forms, publications, etc.

PUBLICATIONS

Progress reports on a number of the Station-sponsored projects as well as special reports on the other Station activities have been published in the scientific and technical journals or in bulletins, circulars, and special reports. During 1948-1949, members of the staff were credited with 32 publications. Of these, three appeared as circulars, 18 as papers in technical journals and organs of technical societies, and 11 as articles in THE RESEARCH ENGINEER. Of the journal articles, seven have been reprinted by the Station. Two major literature searches, one on dry cell technology and the other on water and sewage analysis, have

been published as part of the Station's Special Report Series.

This total by no means represents all of the Station's progress reports, since much of the Station's work is of a confidential nature and does not lend itself to publication at this time. In addition to these publications, the Station has continued to prosecute several patent applications and has filed additional briefs on behalf of sponsors.

RESEARCH PROJECTS

Some 15 major projects and 26 minor projects were inaugurated during the year, while many projects under study prior to July 1, 1948, continued into the past fiscal year, giving the Station considerable work stability. In all, approximately 72 projects were prosecuted during 1948-1949. Of these projects, 40 may be considered major projects involving extensive research programs, while the remaining 32 were minor research programs or special jobs. Thirteen projects were sponsored entirely from Station funds; four were sponsored jointly by the Station and cooperating Government agencies; nine by the Armed Forces; two by other Governmental agencies; and 44 by industries or individuals. Several of the Station's projects have involved extensive research for national defense, and many deal with problems of special interest to Georgia.

An interesting comparison of the type-distribution of the Station's projects since 1942 is given in Figure 3. Attention should be called to the steady annual growth of the number of industrial projects. The development of this service to industry is receiving greater emphasis on the part of the Station, in order that it may play as important a part as possible in the industrial development of Georgia and this region.

Brief descriptions are given below for a number of Station projects which may be openly discussed, or for the brief description of which permission has been obtained from the sponsors involved. As will be noted, those listed do not add up to the total given above, but it was impossible to mention numerous projects for security or contractual reasons.

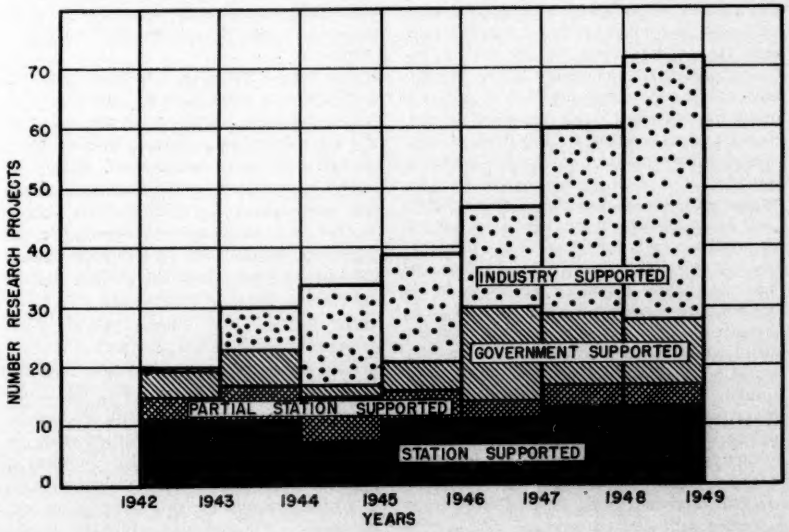


Figure 3. Numerical growth of Georgia Tech Engineering Experiment Station projects, 1942-1949.

Food Preservation Studies. On a project jointly sponsored by the Engineering Experiment Station and the Tennessee Valley Authority, studies have been continued on the fundamental biological, chemical, and physical characteristics of foods as related to their preservation, particularly by freezing. Studies on peaches, strawberries, and beans were made during the past year. Results obtained from these studies on the exact relationship between the time required for freezing and the damage caused by freezing of fruits and berries should be of benefit to commercial freezing plants. Studies are continuing on objective methods needed to characterize changes in quality of foods.

Also in the food field, an investigation related to antioxidants for prolonging the shelf life of special food products has been initiated in behalf of Gordon Foods, Inc.

Fundamental Battery Studies. A project sponsored by the Battery Branch of U. S. Army Signal Corps Engineering Laboratories had as its purpose the development of a method for the electrochemical production of a superior battery-active manganese dioxide. An electrolytic process developed in the laboratory and carried successfully into the semi-pilot plant stage during the past year appears adaptable for the use of domestic low-grade manganese ores. Recent battery test results indicate that the activity of the manganese dioxide produced by the Georgia Tech process exceeds that of any other known synthetic or natural manganese dioxide.

Water and Sewage Studies. Investigations have been continued on the development of rapid methods for the analysis of water, sewage, and industrial wastes. During the past year a new technique has been developed for the determination of fluoride ions. Studies on new methods of analyzing for dissolved oxygen, biochemical oxygen demand, nitrates, and selenium are being continued. This project is conducted under a grant from the National Institute of Health of the U. S. Public Health Service.

Completed this year in the same field was a sanitary analysis of and report on two streams receiving septic tank effluents from a textile mill and its workers' village.

Low Temperature Research. One project, sponsored by the Office of Naval Research, has for its current objective the investigation of elements and compounds for possible superconductivity at very low temperatures (1.5-20° K.). During the past year, magnetic studies of commercially available specimens of lanthanum, cerium, praseodymium, and neodymium have been performed, down to a temperature of 2° K. Of these materials only the lanthanum specimens exhibited the phenomenon of superconductivity, a transition being observed at about 4.8° K. Powder X-ray diffraction studies have been made of these metals, both in an "as received" state and after heat treatment in a vacuum furnace at 350° C. It has been possible to prepare, in this manner, lanthanum metal specimens having hexagonal close-packed and face-centered cubic structures. The relationship of structure to superconductivity is under investigation. Facilities for the analysis of rare earth materials by spectrophotometric, spectrographic, and conventional chemical methods have been set up and are now being used. The preparation of pure rare earth compounds by the use of synthetic ion exchange resins is under way. To date, gram quantities of neodymium and praseodymium oxides of high purity have been prepared.

Nylon Staple Research. Investigations are continuing on the study of the effects of various finishing agents on the processing of stapled nylon fiber. Several finishes were applied and tested on a small scale (50-pound lots). Based on the results obtained, the most promising finishes are being studied in more detail by processing larger quantities for at least 5,000 spindle hours per lot. The sponsor of this project is E. I. du Pont de Nemours & Company, Inc.

Weed Killers. The effectiveness of 2-4D sprays in controlling wild onions was studied in cooperation with the Georgia Agricultural Experiment Station. The minimum concentrations needed to control wild onion growth with the above-type sprays were determined, in addition to the number of applications required. A motor-driven sprayer which controls the rate of spraying and the speed of application (relative to the quantity of spray laid down) was constructed.

Clay Products. During the year, data were obtained on the shape and size of kaolin particles, by means of electron microscope photomicrographs. In addition, the size distribution of particles in several clay samples was obtained by use of an optical micrometer and electron photomicrographs, for industrial sponsors.

Surface Properties of Fine Particles. Research investigations leading to standardization of the surface properties of fine particles are being conducted for the U. S. Signal Corps Engineering Laboratories.

Vegetable Oil Studies. Continued investigations on the extraction of peanut and cottonseed oils by a water grinding process combined with centrifugal separation have shown that this method is technically feasible. Laboratory work on this Station-sponsored project has shown that this method, which has the advantage of using a non-explosive liquid extration medium, yields a clarified protein solution in addition to the oil. The process is now ready for pilot-plant-stage experimentation.

Cellulose and Wood Studies. On another Station-sponsored project, studies have been made on the oxidation of sawdust and the characterization of oxidized cellulose. Conclusions obtained from the former experiments indicate that an increased amount of furfural-yielding oxycellulose could not be produced by high temperature oxidation. Fundamental studies are in progress on the distillation of sawdusts by the fluidized powder technique.

Factice. Still another Station project was concerned with the development of a practical method for the manufacture of factice, a vulcanized oil used in the rubber industry. A method was developed in the laboratory which appears to have significant advantages, on a plant production scale, over presently employed methods.

Heat Transfer. An investigation of the heat transfer properties of three steam coil convectors has been completed for the Larkin Coils Company of Atlanta, Georgia.

Buff Problems. Investigations have been completed in respect to the development of machinery for forming bias cut buffing wheels. Methods of forming these buffs have been developed. This project was sponsored by A. R. Glancy, Inc.

Gasoline Engine Design. A mechanical engineering project, Station sponsored, deals with the development of a new method of carburization for gasoline engines, and a mechanism has been built and adapted to a single cylinder engine. Tests on this engine indicate increased efficiency.

Seed Planter. Research was continued during the year, jointly with the Georgia Agricultural Experiment Station, on construction and field testing (planting tests) of a multi-row, tractor-driven, high-speed seed planter, especially suitable for accurately planting peanuts at even spacings. The planter constructed proved capable of accurate planting at a speed of 15 miles per hour, at which speed each planting unit discharges over 100 seeds per second, one at a time. Earlier types of seed planting equipment do not discharge seeds with sufficent accuracy to permit them to be tractor drawn, even at speeds of less than four miles per hour.

Graphical Methods of Calculation. One Station-sponsored project has as its objective the derivation of improvements in the theoretical foundations of graphical and mechanical methods of computation and the increase of accuracy of the instruments used therefor. A paper has been published on "Graph Papers as Instruments of Calculation," and a second paper on the theoretical background of nomography has been submitted for publication. Other papers are now being prepared on the construction of solid nomographs, mathematical manipulations in nomograph construction, and other theoretical matters based on the aforementioned second paper. A machine for the accurate construction of nomographs is under construction at the present time. Its completion will enable the Georgia Tech Engineering Experiment Station to furnish to industry and research organizations very accurate nomographs in large quantities at a very low cost.

Helicopter Research. Continuation of a School of Aeronautical Engineering project on helicopter development, inaugurated 15 years ago, is intended to augment present knowledge on the helicopter and its flight. During the year, work on the equations for "rigid" rotors was completed, direct solutions being obtained for equilibrium values

of the parameters for steady flight and of the cyclic pitch for steady rates of roll and pitch. Work on hovering flight conditions was continued, and a way was found to integrate the general equations for rotors having blades with linear taper and twist.

Primary effects of blade taper and twist have been evaluated for a helicopter rotor in vertical descent. In the process of running these tests it was discovered that the conventional, previously used methods of measuring the wind tunnel velocity while the rotor was running were inadequate for these tests, and a new and more satisfactory method was devised.

Wind Tunnel Studies. In the field of aeronautical engineering, a number of wind tunnel studies have been made on behalf of several aircraft companies. These have dealt with problems in the aerodynamics of support and control surfaces.

Television Studies. In a project intended to set up a video system for transmission or communication in industrial work, a study of the limiting resolution as a function of the bandwidth has resulted in an indication of the required bandwidth (and complexity and cost of equipment) for the transmission of a given amount of detail in a transmitted picture or scene.

Microwave Propagation. A microwave propagation project has as its research objectives the investigation of the effect of atmospheric conditions, such as ducts, turbulance, and subsidence inversions, on the propagation characteristics of electromagnetic waves in the microwave region, and the determination of the optimum frequency (or frequencies) for a two-way microwave radio relay system with an operating range of 30-50 miles. During the past year, a new type of meteorgraph has been developed which has wide applications. Compilation of data during all seasons of the year resulted in the representation of an annual cycle of weather conditions as related to microwave propagation.

Crystal Controlled Oscillators. Another project deals with research and development work on high-frequency, crystal-controlled oscillator circuits in which the crystal unit operates on a mechanical overtone. New and superior circuits have been developed, and further substantial progress is anticipated on the basis of new circuit theory already developed.

Hydraulic Engineering. For industrial sponsors, several studies in the field of hydraulics have resulted in solution of problems related to the structural modifications of existing hydroelectric power dams and to the structural design of new dams.

A-C Network Calculator. A survey was made, during the year, of nonpower system research uses of a-c network calculators, and analog programs have been envisioned in several fields, such as hydraulics, elastic structures, and heat flow.

As stated previously, these projects by no means exhaust the list of subjects on which the Station is conducting research. Studies not mentioned in detail are continuing on the thermodynamic properties of gases, explosives, radar research and development, emulsions, and gas producers, to mention but a few. Moreover, during the past year, literature searches or surveys were prepared on such subjects as the solvent extraction of vegetable oils, oil and fat antioxidants, food freezing, etc.

Research and developmental service to industry through integrated application of Georgia Tech's research facilities is and has been one of the chief purposes of the Georgia Tech Engineering Experiment Station, followed closely by the desire to add to the nation's storehouse of scientific and technical knowledge. It is the Station's hope and intent that past achievements shall be but the prelude to more important endeavors.

FOOD FREEZING

Continued from Page 2

developed to replace rule-of-thumb techniques. Food freezing fundamentals are under careful study, so that product quality may be improved and new species and varieties frozen commercially. *Much* remains to be accomplished, however. In the meantime, modern armies and—more important—civilians are enjoying the benefits attendant upon a readily available supply of a wide variety of frozen foods, in and out of season for the fresh produce.

REPORT FROM THE LIBRARY

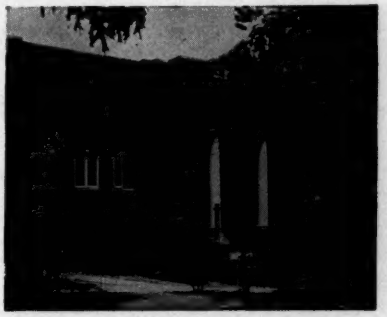
By DOROTHY M. CROSLAND*

The Georgia Tech Library, as is any library in a technological center, is the focal point for knowledge on the campus. Mrs. Crosland, in her previous "Reports," has described in some detail the Library's program, acquisitions, and plans, but she has never before so frankly discussed the almost overwhelming obstacles which it faces.

It has been some months since my last "Report." However, the old adage, "No news is good news," certainly does not hold true in this instance, for I cannot report that a new library building seems any nearer a reality than it did a year ago, five years ago, or even 25 years ago.

Back in the early 'twenties, a campaign was held to raise money for Georgia Tech. In this "Ultimate Plan for a Greater Georgia Tech," a new library was No. 1 on the list of needed buildings, the cost to be $200,000. Five years ago, Georgia Tech's Advanced Planning Committee proposed a new $800,000 library building, which was also to house the Institute's administrative offices. This building was planned for occupancy by the fall of 1949. This past spring, through the generous donation of a friend of Georgia Tech, architects made some drawings of a proposed library building that now would cost $1,500,000. Where are we to get the funds to build this? Suggestions are invited. I might quote Sir William Osler who said, "Money invested in a library gives much better returns than mining stock."

The Georgia Tech Library occupies a strategic position in this region; some librarians and scholars have referred to it as the "regional library for engineering." Its collection numbers approximately 104,000 volumes, including bound periodicals. The Library currently receives, either by purchase or gift, some 1,900 journals from all over the world. Interlibrary loan requests come from all parts of this country and from Canada. We have had requests for information and for the Engineering Experiment Station's publications from England, France, Germany, Sweden, and Switzerland.



We have had repeated inquiries, "Who may use the Georgia Tech Library?" and "Are your facilities and services available to outsiders?" Our first responsibility is to our undergraduate students and to our faculty, then to our graduate students and the research staff of the Engineering Experiment Station. However, because our building is so small and so crowded, both in space for books and for readers, there is no doubt that we give inadequate service even to those who are on our campus. What, then, can we offer to outsiders?

The Library is open each week day, Mondays through Fridays, from 8 a.m. to 9 p.m. (5 p.m., during the summer), and on Saturdays from 8 a.m. to 1 p.m. It is not open on Sundays. From 8 a.m. until 5 p.m. on any day in which the Institute is in session, it is almost impossible to find a seat. One wonders how to answer a student who asks, "Where may I sit to use a reference book?" However, one can usually find a seat and table space from 5 p.m. to 9 p.m.; a professional assistant and a student assistant are on duty and will be glad to help with outside inquiries.

*Librarian, Georgia Institute of Technology.

Because of a lack of personnel—and lack of space for additional help—we cannot give the services to "outsiders" that we hope some day to offer. Until we get a new building, we can answer only reference questions that require little time. Any citizen of Georgia may come into the building to use our collection, but books and periodicals may not be taken from the building, even by alumni. We *do* lend on interlibrary loan to other libraries, however, so if you are an alumnus you may go to the library in your town or city and ask the librarian to request a book which you have seen or used in the Georgia Tech Library. Before too long, we hope to have machinery set up by which all alumni may more readily use our library.

Through the Technical Information Division and the Photographic Laboratory of the Engineering Experiment Station, we can and do extend our services. We can furnish photostats of materials in our collection for 25 cents per page; double pages, 45 cents per copy. A $300 order has recently been completed for the experiment station of another Southern institution. We can give translator service in French, German, Spanish, Russian, and, possibly this fall, Chinese. On request, we send without charge short lists of books, but real bibliographic services are offered only through the Technical Information Division. The following is a brief statement of its services:

"Bibliographies, literature searches (annotated bibliographies), and literature surveys (summaries of the information located) are prepared by the Georgia Tech Engineering Experiment Station's Technical Information Division on a nonprofit basis. Charges consist of: (1) 'personal services' at the hourly salary rate of those so employed, plus a small percentage overhead charge, and (2) the cost of materials (abstract blanks, binders where used, etc.).. Summaries, of course, are rendered as typed reports. Naturally, the actual cost of a given task varies with the nature of the work required. Searching time is minimized by employing typists to do all abstract copying, etc.; some searches require only an hour or two of work. For any specific job, an estimate will be willingly submitted and an agreement signed not to exceed that estimated total. Actual costs on the above basis, which may be less than the estimate, are all that are charged."

These are the services we offer today. With adequate financial support and with a new building, we hope to offer further services to the people of this region; perhaps, in time, to become truly the engineering library for this region.

We are continuing our acquisition program. In the fall of 1948 we were given a donation of $15,000 which was matched by the Board of Regents, making a total of $30,000 available for the purchase of books and periodicals for graduate study and research. With these funds, the following important journals were acquired during the year:

R. Accademia Nazionale dei Lincei, Rome-Atti-Transunti-Memorie-Rendiconti (1873-1939); *Akustische Zeitschrift* (1936-1940); *Akademie der Wissenschaften, Vienna-Mathematisch-Naturwissenschaftlische Klasse-Sitzungsberichte* (1848-1946); *Akademija Uniejetnosci. Krakow-Mathematisch-Naturwissenschaftelische Klasse — Bulletin International* (1901-1935); *American Journal of Hygiene* (1921-1945); *American Statistical Association Journal* (1888-1946); *Archiv für Geschichte der Mathematik der Naturwissenschaften und der Technik* (1908-1931); *Annual Review of Biochemistry* (1932-1944); *British Association for the Advancement of Science—Reports* (1831-1933); *Bulletin des Sciences Mathematiques* (1936-1947); *Canadian Patent Office Record and Registry of Trade Marks* (1890-1930); *Carlsberg Laboratoriet, Copenhagen-Meddelelser* (1876-1934)—*Serie Chimique* (1935-1947)—*Serie Physiologie* (1934-1947) *Flug-Sport* (1929-1943); *Gummi-Zeitung und Kautschuk* (1908-1943); *Industrial Chemist and Chemical Manufacturer, London* (1925-1939); *Industrie Chimique Belgique* (1921-1939); *Institution of Electrical Engineers, London — Wireless Section, Proceedings* (1926-1938); *Intermédiarie des Mathematiciens* (1894-1925); *Korrosian und Metallschutz* (1925-1934); *Matematisk Tidsskrift —B. Advanced* (1919-1946); *Nuovo Cimento* (1894-1948); *Paris. Centre de Documentation Aeronautique Internationale — Fiches*

Continued on Page 23

DIGESTS OF GRADUATE THESES

AERONAUTICAL ENGINEERING
1948-1949

As was the practice last year, this and subsequent issues of THE RESEARCH ENGINEER will contain digests of theses submitted at Georgia Tech in 1948-49 in partial fulfillment of the requirements for Masters' degrees in aeronautical engineering, chemistry, chemical engineering, electrical engineering, industrial engineering, industrial management, mechanical engineering, physics, safety engineering, and textile engineering. All theses so abstracted are available for consultation in the Georgia Tech Library and in the schools to which they were submitted.

Colgan Hobson Bryan, *Apparent Additional Mass Characteristics of Various Bluff Bodies of Revolution.* Faculty advisor: Professor H. W. S. LaVier.

The purpose of this study was the extension of available data and the provision of background for further experiments concerning the apparent additional mass characteristics of various bluff bodies of revolution. For this investigation, a study of basic theory and its historical development provided the logical starting point. Although most of the available data seemed general and incomplete, its importance was evident, since practical applications are made whenever there is accelerated motion of a body through a real fluid.

Previously established facts and empirical formulae indicated the acceptability of conducting experiments in air and water with a simple torsion pendulum. Through the use of standard formulas for moments of inertia and of proper apparatus and procedures, results were obtained which indicate that the apparent additional mass is greater for cylinders having blunt ends than for those having hemispherical ends. Cylinders with conical ends show the least apparent additional mass of those tested. The attitude of cylinders with respect to the direction of motion greatly affects apparent additional mass. Coefficient curves at low fineness ratios are not reliable, but as these ratios increase, mass coefficients tend to become constant (but above the theoretical value of one, which is applicable only in the case of a perfect fluid in which there are no viscosity effects). *M.M.*

Howard Duchacek, *A Study of the Effect of Thickness on Fatigue Strength of 24S-T3 Aluminum Alloy Sheet.* Faculty advisor: Professor G. K. Williams.

Although many investigations have been conducted to determine the effect of size on fatigue strength in the testing of steel specimens, it is only recently that the lighter alloys have been studied. The purpose of the investigation reported in this thesis was to ascertain the effect of thickness in order to determine the variation of fatigue strength in the range of sheet thicknesses used in fabrication of modern aircraft. Four gages of 24S-T3 aluminum alloy sheet, 0.032, 0.040, 0.064, and 0.072 inches thick, were subjected to completely reversed bending stresses parallel to the grain. The investigation was made in the stress range of 18,000 to 48,000 pounds per square inch.

Results of this study show that the effect of thickness on fatigue strength is small in the range of the sizes tested and that the variation of yield point strength or ultimate strength in 24S-T3 material has a greater effect on the fatigue strength than the variation in thickness. Tests on the upper limit of flexural fatigue strength were run for a range of height of specimen from 0.8 to 2 mm., and showed a small decrease in fatigue strength with increase in size. *A.S.C.*

William Russell Haney, Jr., *Design Criteria for Bulb Type Wing Tips.* Faculty advisor: Professor Alan Pope.

A study of existing data on three-dimensional airflow about airplane wing tips—spanwise lift and drag distributions and wing tip vortices—showed variations of flow at the tip which aircraft designers and aerodynamicists approximate with some uncertainty. The investigation reported in this thesis was initiated on the premise that a body of revolution attached at the wing tip

would cause the tip vortex to form on it and would increase the value of circulation at the tip, thereby increasing the average circulation over the wing and therefore the total wing lift.

Wind tunnel tests were performed on comparison of lift and drag for various bulb tips on rectangular wings. It was found that the addition of the bulb tip reduced lift/drag ratio over the complete range of the coefficient of lift. It is believed that this investigation should be extended to include swept back and tapered wings, but this report has determined some criteria that can be used in applying wing tip bulbs to the more practical wing planforms. *A.S.C.*

John Elmer Hatch, Jr., *The Application of the Hydraulic Analogies to Problems of Two-Dimensional Compressible Gas Flow.* Faculty advisor: Professor H. W. S. LaVier.

The hydraulic analogy between water flow with a free surface and two-dimensional compressible gas flow offers a convenient and inexpensive way of investigating such gas flow for phenomena occurring in air at speeds too high for visual observation.

The purpose of this thesis was to design and construct a water channel for investigating the application of this hydraulic analogy to problems of two-dimensional compressible flow. The water channel is especially suited for classroom demonstration of shock wave phenomena. The reflection of shock waves from the channel's walls and the intersection of these shock waves may be observed, as well as the shock waves formed by various shapes. Two supersonic airfoil profiles were tested at various speeds, and pictures were taken of the wave formations set up by each model and of the local water depth distribution about the models. By studying the flow photographs and by applying the hydraulic analogy, an analysis was made of the local conditions about the model. *A.S.C.*

Andrew Rugh Wineman, *The Effect of Scale on the Apparent Additional Mass of Bodies of Revolution.* Faculty advisor: Professor H. W. S. LaVier.

Although other studies had been made in the field of apparent additional mass, it was noted that data were lacking regarding the effect produced by a constant-ratio increase of body dimension. The study reported in this thesis was conducted in an attempt to obtain such data, utilizing mathematical formulas for spherical and other three-dimensional bodies, studied here under conditions of parallel flow in air and water.

Experiments conducted on various bodies of revolution with a simple torsional pendulum substantiate the theory that apparent additional mass increases directly with the scale of the model, but with no scale effect as regards coefficients. Various factors caused the values of the smallest models to deviate from the straight-line ratios of larger models. When compared with results from previous tests, data checked as closely as could be expected. *M.M.*

SYNCHRONIZING UNIT

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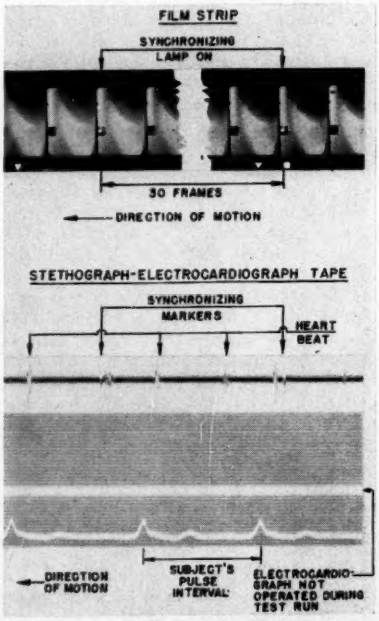

Figure 3. Specimen film strip and stethograph-electrocardiograph tape. The film runs vertically in actual use.

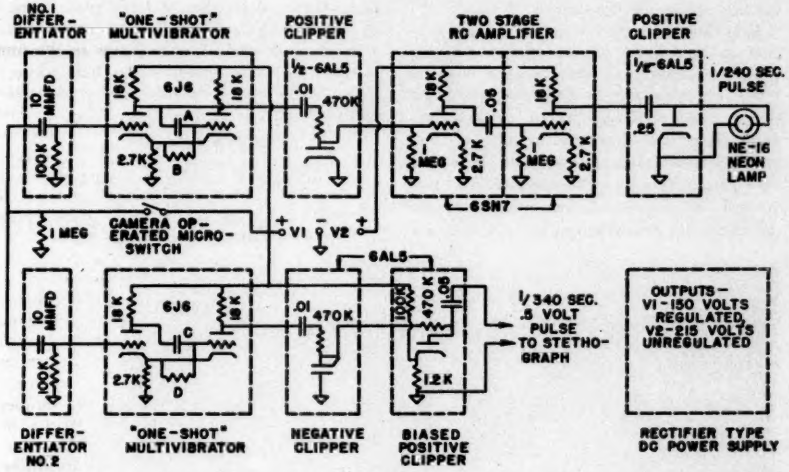

Figure 4. Schematic diagram of the camera-cardiograph synchronizing unit. All filaments are in parallel—transformer CT grounded; resistance values are given in ohms unless otherwise noted; capacitor values are given in microfarads unless otherwise noted; and A, B and C, D are selected combinations for desired pulse width.

applied to the grid of the "one-shot" multivibrator of the lamp channel. One operation of the multivibrator results; its output is a negative voltage pulse that is of 1/240-second duration. This output pulse is then shaped and amplified by the circuits following the multivibrator circuit until there is obtained a square, negative pulse, approximately 120 volts in height. This voltage is applied to the neon lamp which is then lighted for approximately 1/240 second. The output voltage of differentiating circuit No. 2, which coincides in time with that of differentiating circuit No. 1, is applied to the grid of the "one-shot" multivibrator of the marker channel. One operation of the multivibrator results; its output is then shaped by the circuits following the multivibrator circuit and is stepped down to the magnitude required for application to the stethograph, which consists of a resistance-capacitance coupled amplifier driving a recording galvanometer. The shaped output of the marker multivibrator causes the recording galvanometer to deflect and then return to normal 1/340 second later. The start of this deflection coincides with the start of the flash of light produced by the film marking lamp. The above function is repeated for each closing of the camera-driven switch.

The design of this camera-cardiograph synchronizing system is an example of how one scientific field may provide equipment to aid another and of how one institution may assist another to work for the common good of all. Acknowledgement is gratefully made to Dr. F. E. Lowance of the Georgia Tech School of Physics for his many helpful suggestions and to Professor R. L. Allen of the Georgia Tech School of Mechanical Engineering for his work on the modification of the camera and the development of the switch-driving mechanism.

SAMPLE HOLDER

Continued from Page 8

ple is rotating is mathematically equal to the arithmetic mean of a large number of individual readings made at random spots

on the surface of the sample at rest.

Representative curves obtained from samples on the rotating disc are shown in Figure 1. A comprehensive study of the color of green beans is now in progress at Georgia Tech, using this equipment, and present indications are that the important color changes which take place in green beans can be characterized by a few readings and that it will be possible to construct a simple photoelectric device to apply this information. Such a device would be of great value in the quality control of green vegetables. Further work should extend this usefulness to other materials, especially to those whose color cannot readily be analyzed by previous methods.

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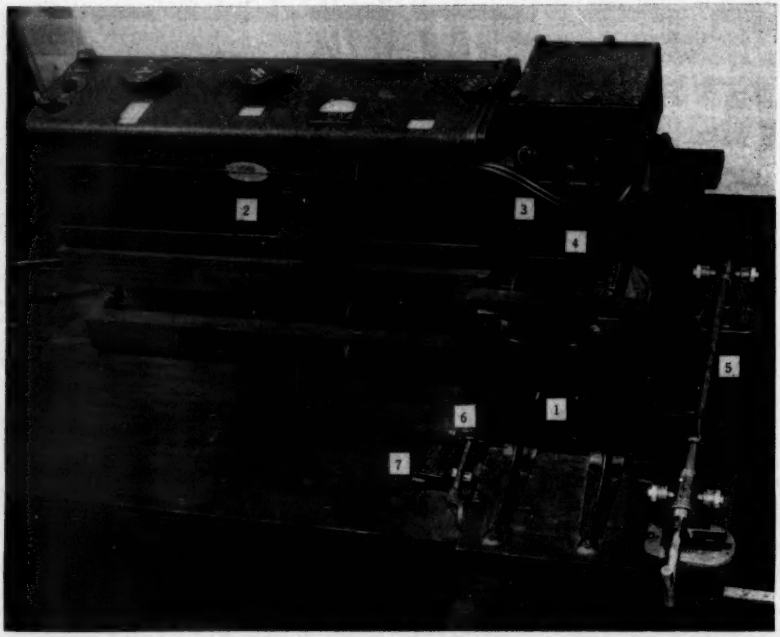

Figure 4. The rotating disc assembly mounted with the spectrophotometer and reflectance accessory.

1. *Rotating disc assembly.*
2. *Spectrophotometer (Beckman Model DU).*
3. *Reflectance accessory (Beckman No. 5280).*
4. *Blackened brass plate fitted in chamber to provide a light-tight seal between the reflectance accessory and the rotating disc assembly.*
5. *Stops to control either the position of the sample or the standard beneath the reflectance accessory.*
6. *Spring and check to maintain the rotating disc assembly in position.*
7. *Automatic switch which turns on the motor to drive the rotating disc when the disc is in the proper position for reflectance measurement.*

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The following publications have been released by the Station since those reported in the May, 1949, issue of THE RESEARCH ENGINEER.

REPRINTS

R. S. Ingols and P. E. Murray, *Urea Hydrolysis for Precipitating Calcium Oxalate*, Georgia Institute of Technology Engineering Experiment Station Reprint No. 33, 1949. 3 pages. 25 cents.

This article, reprinted from the April, 1949, issue of *Analytical Chemistry*, describes the use of the hydrolysis of urea for raising the pH of a solution containing calcium and oxalate ions; this technique permits the formation of large, readily filtered crystals of calcium oxalate. These crystals are less contaminated by magnesium or aluminum oxalate, or excess oxalate due to the presence of the sulfate ion, than are the smaller ones formed by use of the standard method, while the over-all time for a set of duplicate determinations for calcium is reduced by this method from 90 minutes to 40 or 50 minutes.

Alan Pope, *Summary Report of the Forces and Moments Over an NACA 0015 Airfoil: Through 180° Angle of Attack*, Georgia Institute of Technology Engineering Experiment Station Reprint No. 34, 1949. 3 pages. 25 cents.

This summary, reprinted from the April, 1949, issue of *Aero Digest*, reports the measurement of force and pressure distribution over an 18-inch chord NACA 0015 airfoil in the Georgia Tech 2.5 x 9 foot, two-dimensional wind tunnel through 180° angle of attack. An IAS = 80 mph. was used, yielding an RN_e = 1,230,000 under tunnel conditions.

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No. 15. *Proceedings of the Broadcast Engineers Conference*, by M. A. Honnell and B. H. Weil (Editors), 1947. Four Dollars.

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